



IAQ and Student Performance

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IAQ & Student Performance

Overview

- Review causes of poor indoor air quality (IAQ)
- Discuss general considerations for measuring student performance & IAQ
- Review selected studies and results
- Summary



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Review

- Causes of Poor Indoor Air Quality
 - Failure to control pollutant sources
 - For example, art supplies, lab activities, cleaning & maintenance supplies
 - Failure to control temperature and humidity
 - Failure to control moisture and spills





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Review cont'd

- Causes of Poor Indoor Air Quality
 - Failure to ventilate each classroom adequately
 - Failure to perform housekeeping and maintenance adequately or properly
 - Failure to use integrated pest management





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What We Know

- Large amount of information on health effects of poor IAQ
- Relatively few studies of student performance and IAQ (but growing)
- Very difficult area to study
- Must examine studies of office workers as well



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- Why is performance so difficult to study?
 - Many variables can affect student performance
 - IAQ is only one of the variables (and IAQ is multifactorial also)
 - Variables are difficult to control
 - There are many confounders

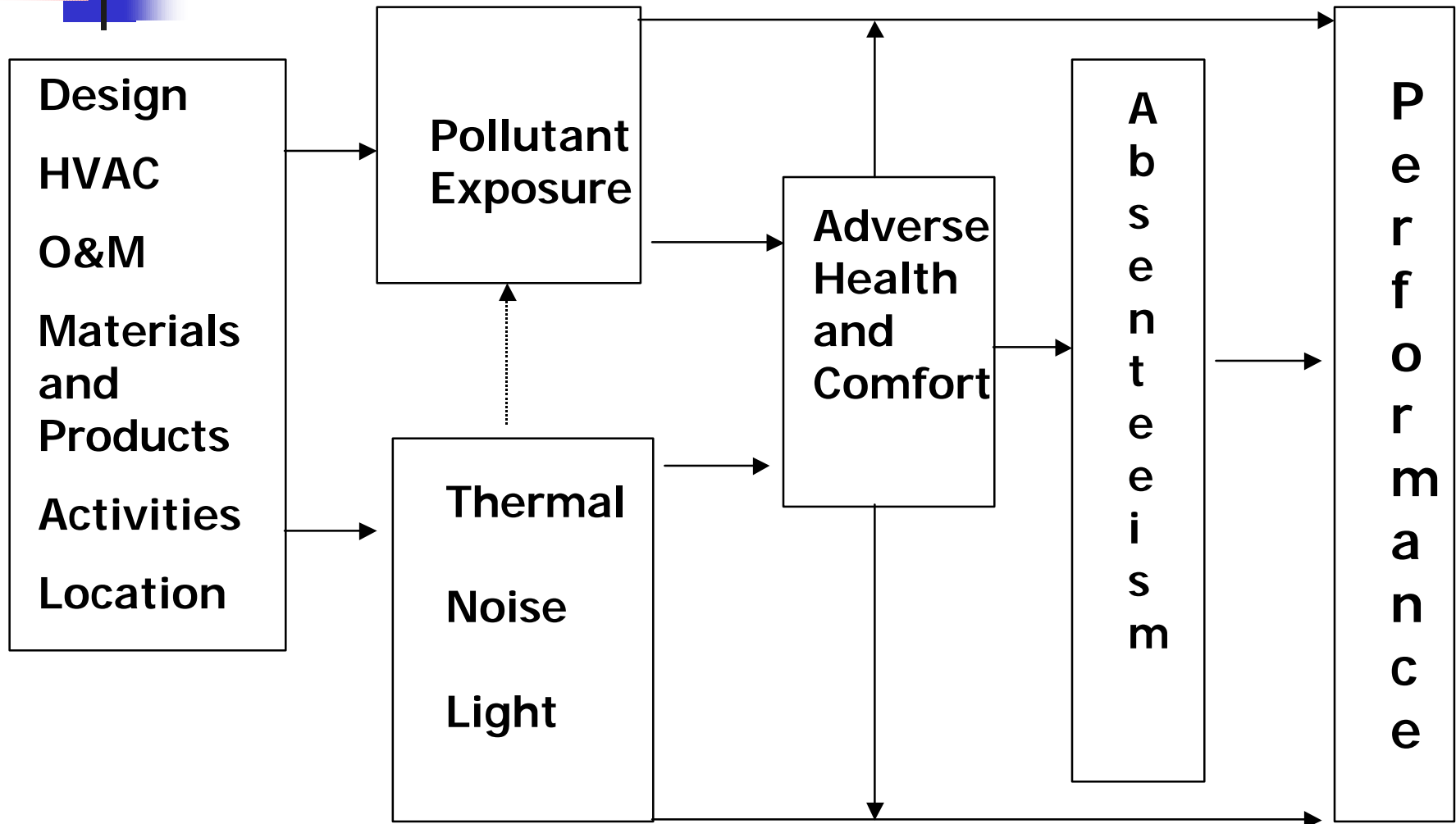




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- Examples of variables that can affect student performance
 - Curriculum changes
 - Home situation
 - Infectious disease
 - New students or teacher
- IAQ is multifactorial (also has many variables)
 - Environmental parameters (chemicals, biological contaminants, particulate matter)
 - Thermal factors (temperature, relative humidity, air velocity)
 - Ventilation

How Does IAQ Affect Performance?



IAQ & Student Performance

- How can we measure student performance?
 - Standardized tests
 - Grades and teacher evaluations
 - Absenteeism (indirect)
 - Health and comfort (indirect)
 - Self assessments (direct/qualitative)





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- Standardized Tests
 - Can measure effects but could be small (need controls)
 - More sensitive measure
 - Becoming more common
 - Still sensitive to confounders
 - Year to year variations normal



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- Teacher Evaluations and Grades
 - Teachers grade differently
 - Insensitive to small changes in performance
 - Subject to confounding
 - Quarterly/yearly variations normal



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- Absenteeism
 - Effect is easily measured
 - But relatively crude measure
 - Doesn't measure decrements in performance while at school
 - An epidemic or high pollen counts outdoors can compromise study



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- Types of Studies
 - Chamber vs. Field Studies
 - Longitudinal (follow in time) vs. Cross-sectional (extensive snapshot in time)
 - Intervention Studies
 - Pre-intervention measurement; intervention; post-intervention measurement

Quality of Studies

- Large number of subjects helps but cost rises
- Having controls is usually critical
- Subjects should be blinded to interventions--often difficult





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- Molhave Study-Danish (1984)
 - Chamber study of 66 adults w/sensitivity to IAQ; exposed to 22 VOC
 - Subjects could perceive poor IAQ & reported mucous membrane irritation
 - Poorer performance on a short term memory test with exposure to VOC (possible increased stress and lower concentration)



IAQ & Student Performance

- EPA Study (1992)
 - Intended to confirm Molhave Study
 - Chamber study of 66 adult males w/o sensitivity to IAQ; exposed to 22 VOC
 - Subjects could perceive poor IAQ & reported mucous membrane irritation
 - Subjects did not have poorer performance on a short term memory test with exposure to VOC



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- Danish Studies on Thermal Effects on Performance (1974-2002)
 - Simulated controlled office environment
 - Cooler temperatures and lower RH within comfort zone associated with lower symptoms, improved IAQ perception and improved performance (mixed)
 - Conditions for highest performance not same as greatest comfort



IAQ & Student Performance

- Swedish Study, 800 students, 8 schools (1996)
 - Related CO₂ to student performance and symptoms (also measured VOC, RH, T but not reported); ages 15 to 20
 - Both health indices (headache, tiredness, difficulty concentrating; and eye and upper airway irritation) correlated positively to CO₂ concentration (lower ventilation, more crowding)
 - Performance (tests of concentration) decreased with higher CO₂ concentrations (lower ventilation, more crowding)



IAQ & Student Performance

- Why measure CO₂?
 - Everyone expires CO₂
 - CO₂ can be used as a measure of ventilation relative to the number of people present in a given space (a surrogate for poor ventilation)
 - CO₂ does not generally cause health effects at levels observed in typical indoor environments
 - CO₂ levels would have to be extremely high to cause lethargy or tiredness





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- U.S. Corporate Office Study (2000)
 - Polaroid corporation offices, cross sectional study
 - Lower ventilation rates consistently associated with increased short term sick leave.
 - Use of humidification also associated with increased short term sick leave



IAQ & Student Performance

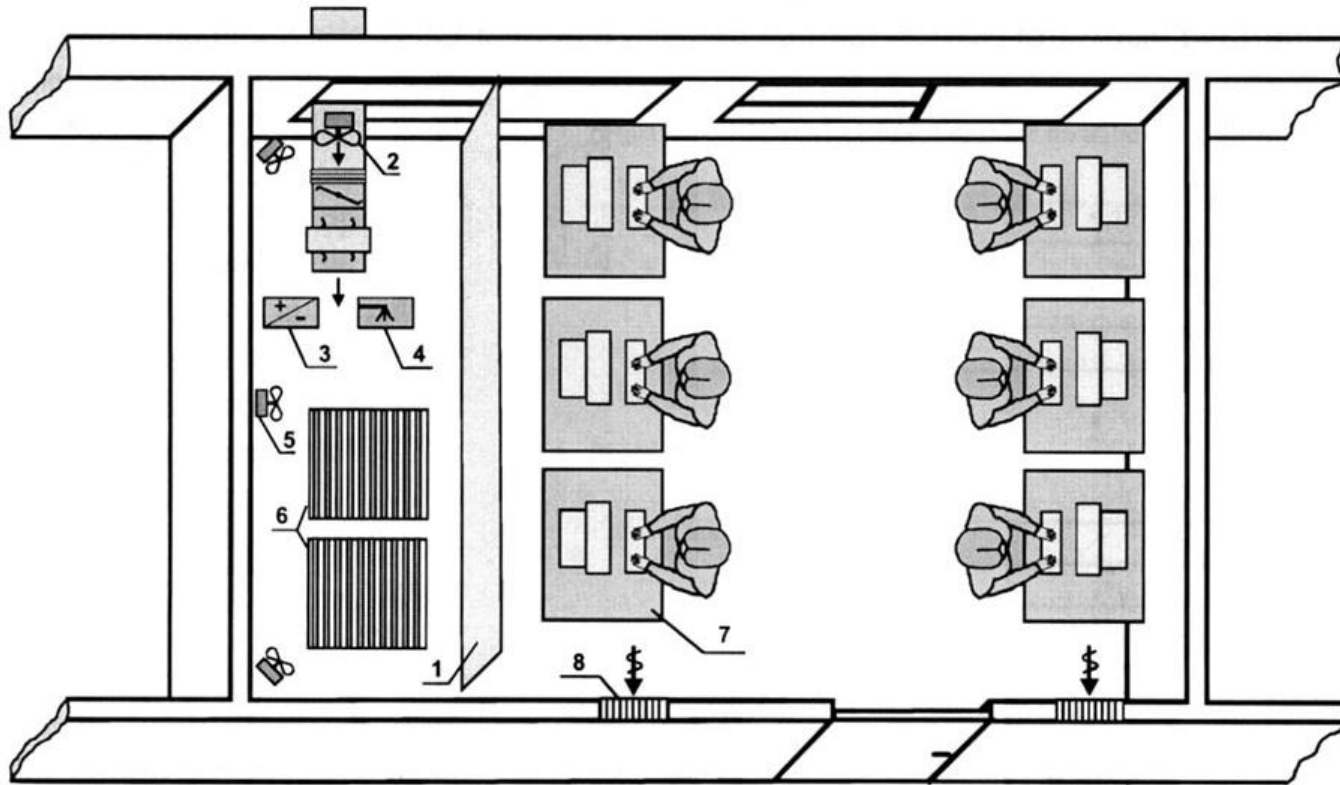
- U.S. Corporate Office Study (2002)
 - Polaroid corporation offices, cross sectional study
 - Lower ventilation rates not associated with increased short term sick leave
 - Previous study had larger study area and larger ventilation differences
 - However, this study had more CO₂ measurements
 - Ventilation rates not believed to be low enough to increase transmission of colds



IAQ & Student Performance

- Danish Controlled Field Study (2000)
 - Modified a room in an existing office
 - IAQ Controls: Large changes in ventilation or the introduction of a hidden 20-yr old carpet
 - 30 female subjects (20 to 31 years old) w/o history of respiratory illness
 - Studied perceived IAQ, reported symptoms, performed typing, proof-reading & addition; took psychological tests

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Schematic of Test Facility



IAQ & Student Performance

- Danish Controlled Field Study (2000)
 - Perception of IAQ and performance on text typing, proof-reading & addition all improved with better IAQ
 - Headaches more severe with pollutant source ($p < 0.04$)



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Test	Effect	Description	p-value
Typing	6.5 %	More typed characters	<0.03
Typing	5 %	Fewer errors	<0.10
Addition	3.8 %	More numbers added	<0.05
Logical reasoning	3.4 %	Increased reaction time	<0.08
Serial addition	2.5 %	More accurate addition	<0.06
Stroop	3.1 %	Increased speed	<0.10



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Word Set #1

RED	GREEN	BLUE	YELLOW	PINK
ORANGE	BLUE	GREEN	BLUE	WHITE
GREEN	YELLOW	ORANGE	WHITE	BLUE
BROWN	RED	BLUE	YELLOW	GREEN
PINK	YELLOW	GREEN	BLUE	RED



IAQ & Student Performance

Word Set #2

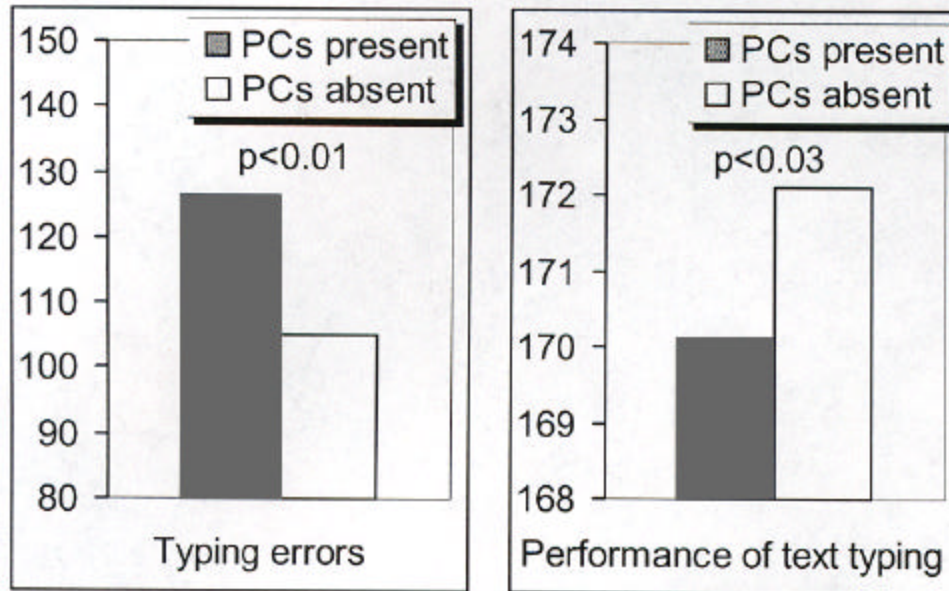
RED	GREEN	BLUE	YELLOW	PINK
ORANGE	BLUE	GREEN	BLUE	GRAY
GREEN	YELLOW	ORANGE	BLUE	GRAY
BROWN	RED	BLUE	YELLOW	GREEN
PINK	YELLOW	GREEN	BLUE	RED



IAQ & Student Performance

- Danish Controlled Field Study (2002)
 - IAQ Controls: presence or absence of six operating, but hidden, 3-month old used, personal computers
 - Perception of IAQ and performance on text typing, proof-reading & addition all improved with better IAQ
 - Creative thinking improved with ventilation

IAQ & Student Performance



- Performance is a measure of both typing errors and speed
- Performance decreased by 1.2% when PCs were present



IAQ & Student Performance

- **Charles Young School (2002)**

- Inner city school in great disrepair
 - Extensive water damage (roof leaks, rotting windows, broken steam & hot water pipes)
 - Extensive visible mold growth
 - Most exhaust fans broken
 - HVAC system did not work
 - Serious pest infestation (cockroach, birds)
 - Discarded, unknown chemicals on mechanical room floor
 - Peeling lead paint



IAQ & Student Performance

- Charles Young School (2002)
 - Extensive renovation (1997-98)
 - Roofing and masonry repaired
 - Moldy and water damaged materials replaced
 - Leaking ducts, steam and water pipes replaced
 - Abandoned 55 gal drums of chemicals removed
 - Bird debris removed and pest barriers installed
 - Carpet replaced; training and vacuums provided
 - Lead paint removed or contained
 - All windows replaced
 - HVAC system received major overhaul



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- **Charles Young School (2002)**
 - Attendance rose from 89 % to 93 %
 - National test scores—intriguing results

Standard Test Results	Before 1996	After 2000
Math Scores	Basic or Above 51 %	Basic or Above 76 %
Reading Scores	Basic or Above 59 %	Basic or Above 75 %



IAQ & Student Performance

- Health, Energy & Productivity Study (currently underway)
 - Pilot-level study in Montgomery Co., MD
 - Both public & private support
 - Standardized test scores, absenteeism, quarterly report cards
 - Longitudinal 3-yr. study of 3rd & 4th grade
 - 2 sets of matched triplet schools: Controls, IAQ only, IEQ (acoustics & lighting)



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- Critical Literature Review (2002)
 - Conducted by LBNL
 - Direct & indirect evidence- no silver bullet
 - Performance effects not large (2%-6%)
 - Will update our Fact Sheet on the Web
 - Journal publication planned in journal for educational research community (*Review of Educational Research*)

IAQ & Student Performance

- Summary

- Studies suggest poor IAQ degrades student performance (also very plausible)
 - Evidence is building--slowly
- Good studies are difficult and expensive
- Need to examine studies in other environments (e.g., offices)
- Need to interest educational research community

